DIETARY REFERENCE INTAKES

FOR

Water, Potassium, Sodium, Chloride, and Sulfate

Panel on Dietary Reference Intakes for Electrolytes and Water

Standing Committee on the Scientific Evaluation of Dietary Reference Intakes

Food and Nutrition Board

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"Knowing is not enough; we must apply.
Willing is not enough; we must do."
—Goethe

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Preface

This report is one in a series that presents a comprehensive set of reference values for nutrient intakes for healthy U.S. and Canadian individuals and populations. It is a product of the Food and Nutrition Board (FNB) of the Institute of Medicine, working in cooperation with Canadian scientists.

The report establishes a set of reference values for dietary electrolytes and water to expand and replace previously published Recommended Dietary Allowances (RDAs) and Recommended Nutrient Intakes (RNIs) for the United States and Canada, respectively. Close attention was given to the evidence relating electrolyte intake to the risk of high blood pressure and hypertension, as well as other diseases, and the amounts of water from beverages and foods needed to maintain hydration. In addition, since requirements for sulfur can be met by inorganic sulfate in the diets of animals, a review of the role in inorganic sulfur in the form of sulfate is included.

The group responsible for developing this report, the Panel on Dietary Reference Intakes for Electrolytes and Water, under the oversight and assistance of the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes (the DRI Committee), has analyzed the evidence on risks and beneficial effects of nutrients included in this review.

Although all reference values are based on data, available data were often sparse or drawn from studies with significant limitations in addressing various questions confronted by the panel. Thus, although governed by scientific rationales, informed judgments were often required in setting these reference values. The reasoning used

in evaluating each nutrient is described in Chapters 4 through 7. Chapter 3 outlines the risk assessment approach used to establish the reference values for upper intake levels as developed and further modified by the DRI Subcommittee on Upper Reference Levels. Chapter 8 addresses major conceptual issues related to the uses of the DRIs that were included in the early stages of the DRI process and have been developed further as described in reports from the Subcommittee on Interpretation and Uses of Dietary Reference Intakes.

While the quantity of research reports relating sodium and potassium intake to blood pressure is quite large, the quality of the research useful to the panel for setting requirements of sodium and potassium was limited. In particular, there was a dearth of large, dose-response studies with clinically relevant biological outcomes carried out in normal, apparently healthy individuals.

Given the ability of many humans to adapt to varying amounts of electrolyte intake and the impact of temperature and activity level on needs of electrolytes and water, it was not possible to determine Estimated Average Requirements (EAR) for these nutrients. Instead, Adequate Intakes (AIs) were set for sodium, potassium, and water. No AI was set for sulfate as there is sufficient sulfur in the human diet from foods (derived from sulfur amino acids) and water to meet the needs of healthy individuals. No specific Tolerable Upper Intake Levels (ULs) were set for water, potassium, or sulfate as healthy persons can adapt to higher intakes from foods and beverages. In contrast, a UL was set for sodium based upon the increased risk of cardiovascular outcomes, particularly cardiovascular disease and stroke.

Readers are urged to recognize that the DRI process is iterative in character. The FNB and the DRI Committee and its subcommittees and panels fully expect that the DRI conceptual framework will evolve and be improved as novel information becomes available and is applied to an expanding list of nutrients and other food components. Thus because the DRI activity is ongoing, comments have been solicited widely and received on the published reports of this series. Refinements that resulted from this iterative process were included in the general information regarding approaches used (Chapters 1 and 2 and in the discussion of uses of DRIs in Chapter 8). With more experience, the proposed models for establishing reference intakes of nutrients and other food components that play significant roles in promoting and sustaining health and optimal functioning will be refined. Also, as new information or new meth-

ods of analysis are adopted, these reference values undoubtedly will be reassessed.

Many of the questions that were raised about requirements and recommended intakes could not be answered satisfactorily for the reasons given above. Thus among the panel's major tasks was to outline a research agenda addressing information gaps uncovered in its review (Chapter 9). The research agenda is anticipated to help future policy decisions related to these and future recommendations. This agenda and the critical, comprehensive analyses of available information are intended to assist the private sector, foundations, universities, governmental and international agencies and laboratories, and other institutions in the development of their respective research priorities for the next decade.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

> Michael Alderman, Albert Einstein College of Medicine; John R. Claybaugh, Tripler Army Medical Center; David Cole, University of Toronto; Gary Curhan, Harvard University; Johanna T. Dwyer, Tufts New England Medical Center; Shiriki K. Kumanyika, University of Pennsylvania; Gary W. Mack, Yale University; Melinda Manore, Oregon State University; Timothy Noakes, Sports Science Institute of South Africa; Suzanne Oparil, University of Alabama at Birmingham; Frank Sacks, Harvard University; Judith Stern, University of California at Davis.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by John W. Suttie, University of Wisconsin, appointed by the Institute of Medicine, who was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final

content of this report rests entirely with the authoring panel and the institution.

The support of the Canadian government and Canadian scientists' participation in this initiative are gratefully acknowledged. This close collaboration represents a pioneering first step in the harmonization of nutrient reference intakes in North America. A description of the overall DRI project and of the panel's task is given in Appendix B.

The DRI Committee and the Panel on DRIs for Electrolytes and Water extend sincere appreciation to the many experts who assisted with this report by giving presentations to the panel, providing written materials, participating in the groups' open discussions, analyzing data, reviewing the report, and other means. Many, but far from all, of these individuals are named in Appendix L. Special gratitude is extended to the staff at ENVIRON International Corporation for providing national survey data.

The Panel on DRIs for Electrolytes and Water performed their work under great time pressure. Their dedication made the report's completion possible. All gave their time and hard work willingly and without financial reward; the public and the science and practice of nutrition are among the major beneficiaries of their dedication. Special thanks go to DRI Committee members Robert Russell, Joseph Rodricks, and Susan Barr for assisting the Panel in its review. In addition, the DRI Committee thanks the staff responsible for its development—in particular Paula Trumbo who served as a program officer for the study through June 2003, Allison A. Yates, who stepped in as Paula's replacement, and Crystal Rasnake, research assistant on the project in the later phases of its completion and key to organizing the many references and tables. The intellectual and managerial contributions made by these individuals to the report's comprehensiveness and scientific base were critical to fulfilling the project's mandate. Sincere thanks also go to other FNB staff, including Carrie Holloway, Mary Poos, Gail Spears, and Sandra Amamoo-Kakra, who also contributed their efforts over the years to complete this document.

And last, but certainly not least, the DRI Committee wishes to extend special thanks to panel chair Larry Appel, who oversaw the entire report development process, to Vernon Young, past chair of the DRI Committee, and to Cutberto Garza, former Chair of the Food and Nutrition Board, under whom this study was initiated.

John Erdman
Chair, DRI Committee

Postscript:

Following release of the report in pre-publication copy form, the Panel and DRI Committee were saddened to learn of two untimely events: the deaths of both Lawrence M. Resnick, M.D., a member of the Panel who was steadfast in his views while congenial in his search for approaches that were scientifically supportable; and Vernon R. Young, Ph.D., who, as the first chair of the DRI Committee, led the pursuit of integrating good science into nutrient-based reference values while challenging all those involved to think past old axioms as the term "nutrient" was redefined; he was a true scholar.

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